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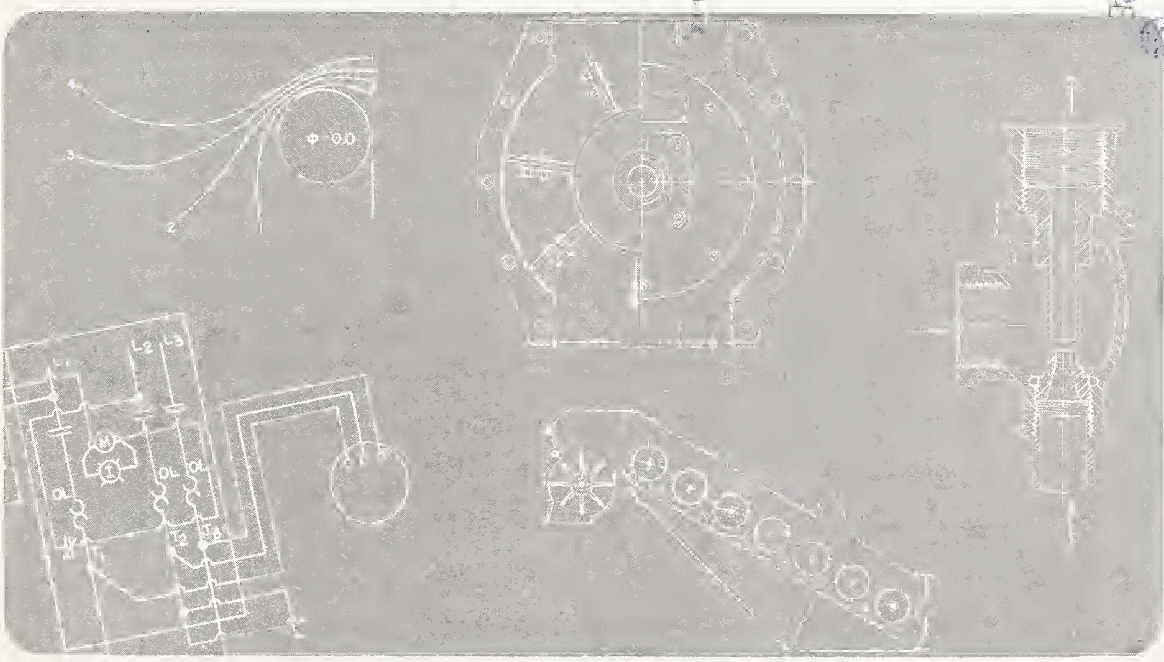
Making Plastic Bandoleers and Growing Plants in Them



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Making Plastic Bandoleers and Growing Plants in Them

By Kathryn A. Ray and Victor L. Hauser[1]

ABSTRACT

This publication describes a new system for making bandoleers consisting of two sheets of 2-mil-thick polyethylene plastic film heat-welded together to form a series of belt-supported cells (pockets) containing a medium for growing plants. After the plants are established, the bandoleers are fed through a transplanting machine that cuts each cell free and sets the plants in the soil. Thus, the bandoleer permits complete mechanization of growing and transplanting plants and should reduce the costs involved. The detailed plans and specifications presented will readily enable duplication and operation of the equipment. Methods for growing grass in the bandoleers under greenhouse conditions are also included. Index terms: bandoleers (plastic), establishing seedlings, grasses, greenhouse procedures, planting seeds, transplanting plants.

INTRODUCTION

The plastic bandoleer was conceived to enable complete mechanization of the grass-transplanting process. This report describes the required equipment and construction methods for making bandoleers and the procedures for growing plants in them for research at the Agricultural Research Service's Grassland, Soil, and Water Research Laboratory at Temple, Tex.

The bandoleer is a long belt containing cells (pockets) that hold a medium in which plants can be grown. After the plants are established in the cells, the bandoleer is fed through a transplanting machine that cuts each cell free and sets the plants in the soil. The bandoleer permits complete mechanization of growing and transplanting plants; thus, it should reduce the cost of transplanting.

Two sets of equipment were built at Temple to make two sizes of bandoleers, but the dimensions given in this publication are for the small bandoleer equipment only. The small bandoleers were 0.313 inch in diameter and 2.362 inches long, and the center-to-center cell spacing was 0.468 inch. The large bandoleer cells were 1.250 inches in diameter and 4.500 inches long, and the center-to-center spacing was 1.400 inches. Equipment to make large bandoleers can be scaled-up from the drawings presented herein for small bandoleers.

The equipment and methods were developed over a 5-year period (1977–82) beginning with Brewer's ideas (Brewer 1978). They were used by Chichester (1981), Moden and Hauser (1982), and Hauser (1982, 1983).

The bandoleers were made of two sheets of 2-mil-thick polyethylene plastic film heat-welded together to form cells (fig. 1) that were filled with nursery mix and planted with grass seeds. The bandoleers were then placed in the greenhouse for germination and seedling establishment. Routine maintenance for growing the grass plants included trimming them back to 2 inches of height after they had reached a height of 3–4 inches. Before

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the seedlings were taken to the field, they were trimmed back to a height of 1 to 1.5 inches. When the plants were sufficiently established, they were planted in the field by transplanter or by hand.

EQUIPMENT AND SUPPLIES

We constructed a vacuum mold to hold the limber 2-mil-thick polyethylene plastic in the desired shape during cell forming. Each small bandoleer section contained 20 cells that were formed and filled in the vacuum mold. The cells were filled with a prepared nursery mix by means of special filling trays, funnels, and tampers.

Heat-welding was the easiest method for joining the plastic between cells. We heat-welded the plastic by burning holes in a line at the joint. When an attempt was made to make a continuous line-type weld (instead of holes), a weak joint often occurred if the weld temperature was low, or the bandoleer was severed if the heat was excessive. When the plastic was joined by burning holes in it, excessive heat caused little or no problem, so the welding temperature could be set above the minimum temperature required to fuse the plastic films. Thus, reliable joints were produced with this method. Since the bandoleers were made in sections of 20 cells each, the sections had to be joined together to make a continuous bandoleer. Therefore, we built a three-cell false mold to hold the bandoleer sections in the correct position while they were being joined together by heat welding.

The supplies and equipment that we used for each step in the construction procedure are described below. All of the equipment was built at Temple except the following items: vacuum pump and accessories, transformer, power stat, welding clamps (which we modified), and soldering iron. Some of these items could be modified or replaced to fill particular job requirements.

A. Cell forming
   1. Plastic, 2-mil-thick polyethylene sheeting (Acme Bag Manufacturing Co., Inc., Dallas, Tex.) in rolls 2.4 inches wide; 16.25-inch length needed to form one bandoleer section in cell mold.
   2. Vacuum pump, model 2065–V4B–T334 (Gast Manufacturing Corp., Benton Harbor, Mich.), with 10-gallon vacuum reservoir; vacuum controlled with electric vacuum solenoids; maximum vacuum created, 25 inches of mercury; connects to cell mold.
   3. Cell mold, device in which bandoleer is formed; made from solid aluminum block (figs. 2–4).
   4. Former, used to press 2-mil-thick plastic strips against vacuum holes in cell mold; former is made of standard wood pencil pieces about 2.5 inches long (fig. 5); pieces are placed in cell mold, and two strips of fiberglass packaging tape (one on top of the other) are put on top of pencil pieces; form completed by turning under excess tape to create lifting handles.
   5. Funnel set, used to pour planting mixture into each cell (figs. 3 and 6).
   6. Welding clamps, modified Vice Grip (Petersen Manufacturing Co., Dewitt, Nebr.) for holding cell mold together (figs. 4 and 7).

B. Cell filling
   1. Planting mixture, Terra-Lite Redi-Earth potting soil (W. R. Grace & Co., Cambridge, Mass.); peat and vermiculite mixture is passed through a 0.125-inch sieve and then finely ground to permit placing mixture in the small bandoleer cells.
   2. Mix tray, used to measure planting mixture (figs. 4 and 8).
   3. Tamper, used to pack planting mixture in individual cells (fig. 9).

(Continued on page 8.)

FIGURE 1.—Large-cell plastic bandoleers containing seedling eastern gamagrass, *Tripsacum dactyloides* L., plants.

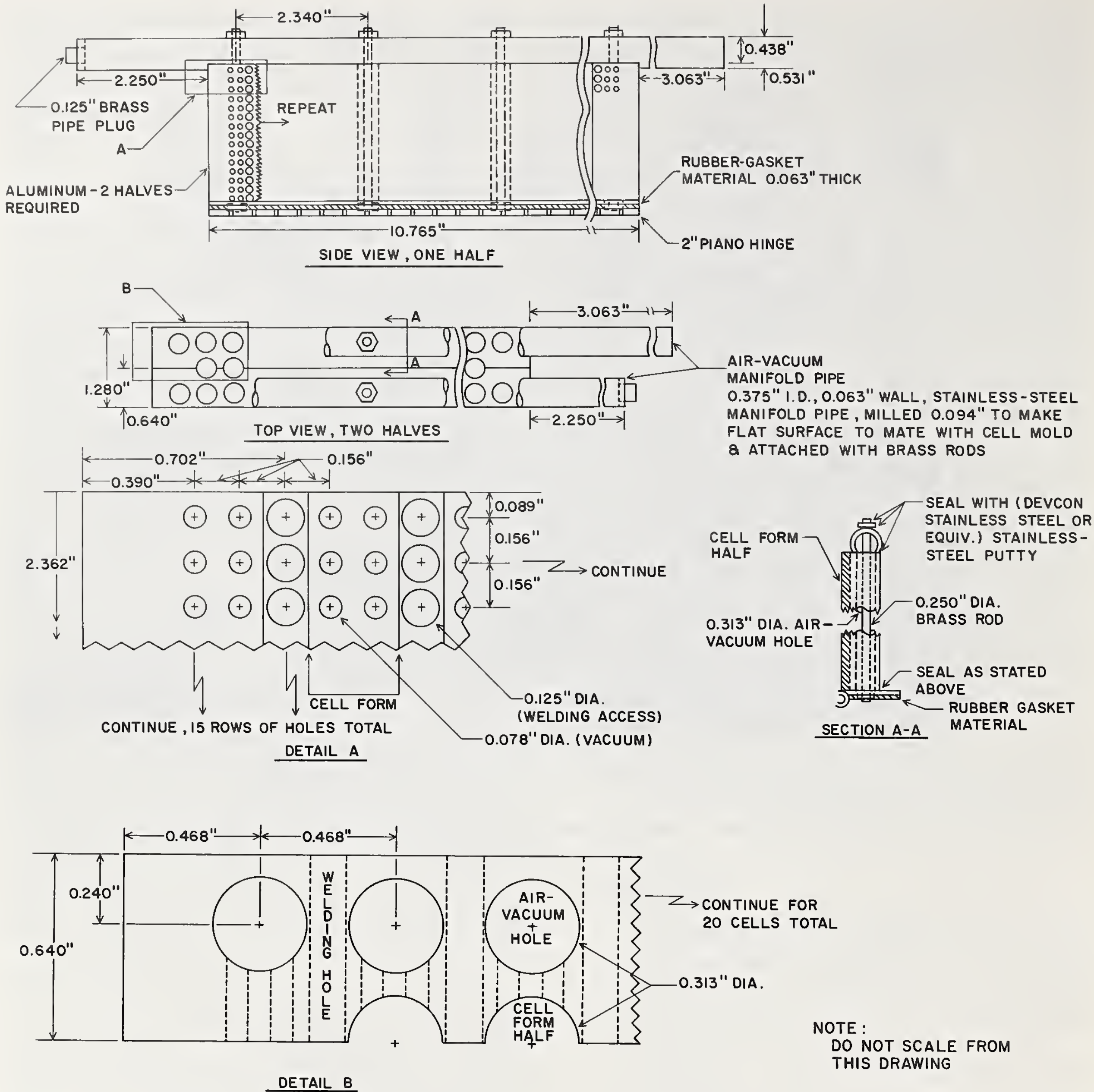

FIGURE 2.—Details of cell mold in which bandoleer is formed.

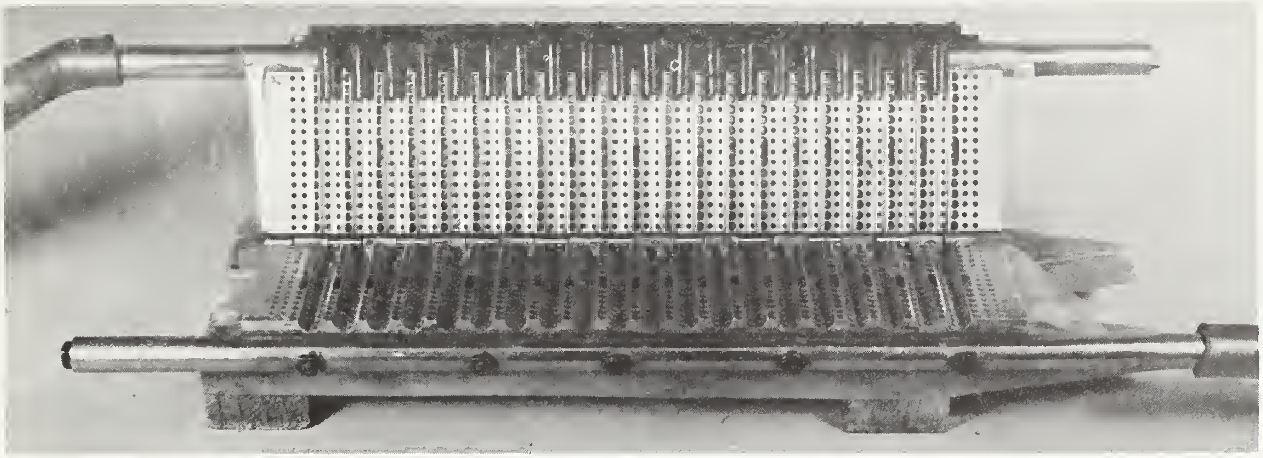

FIGURE 3.—Cell mold with plastic strips being held by vacuum provided by attached vacuum hoses. Funnel set is attached to top of cell mold. (Slot shown in center of each set of welding holes was an experimental modification that was abandoned and is therefore not included on detailed drawing in figure 2.)

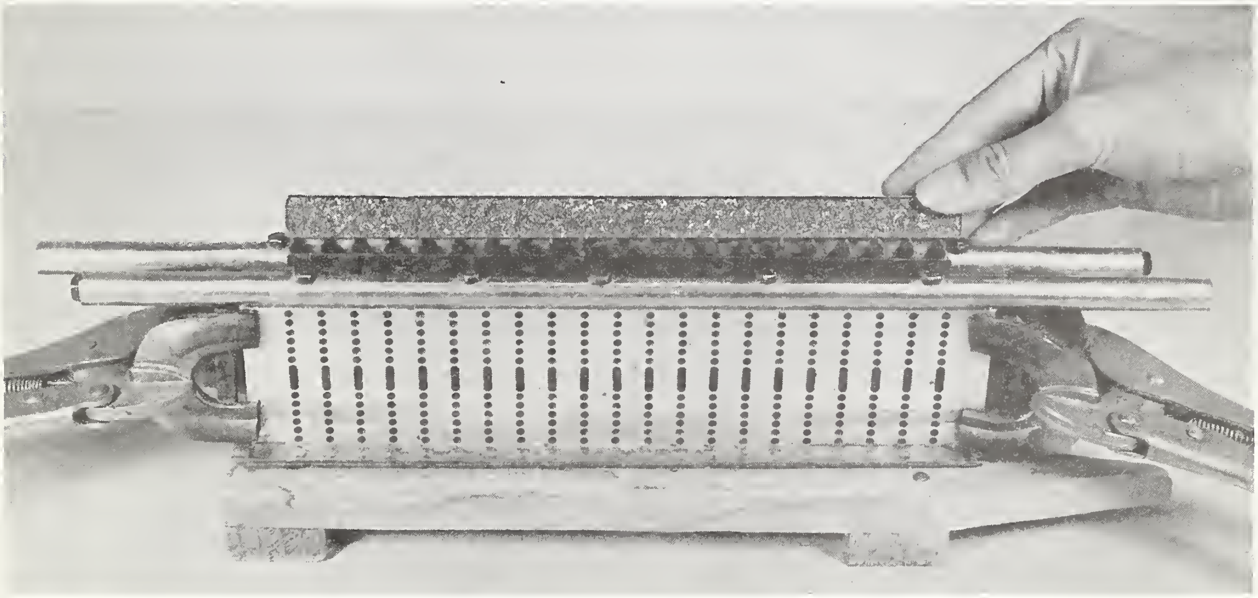

FIGURE 4.—Cell mold being held together with clamps while planting mixture in mix tray is poured through funnel set. Notice that vacuum hoses are disconnected.

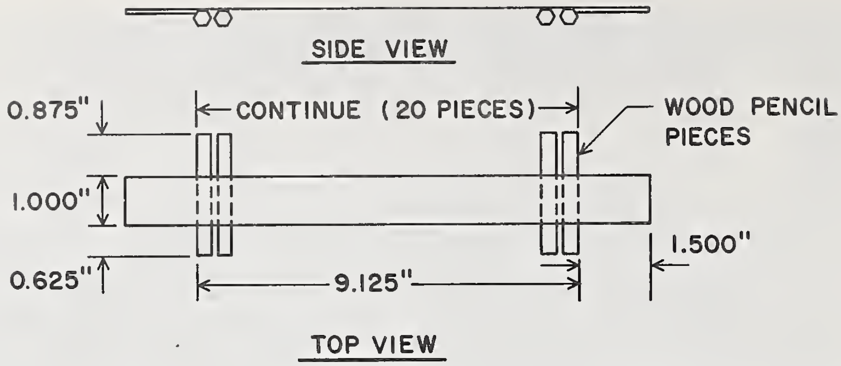

Figure 5.—Details of former used for pressing 2-mil-thick plastic strips against vacuum holes in cell mold.

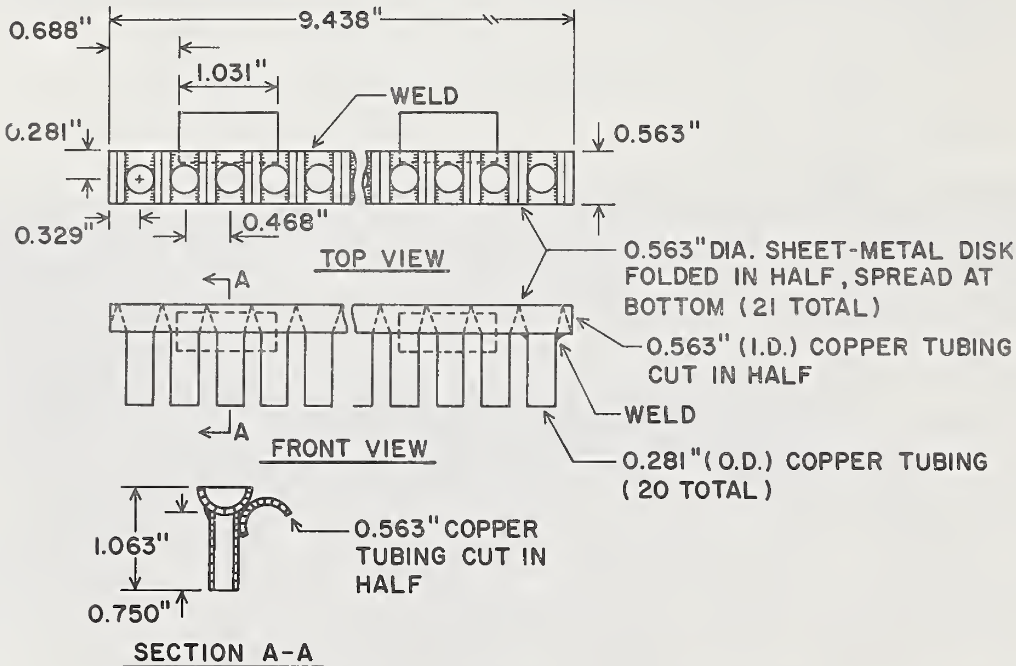

Figure 6.—Details of funnel set used for pouring planting mixture into each cell of bandoleer.

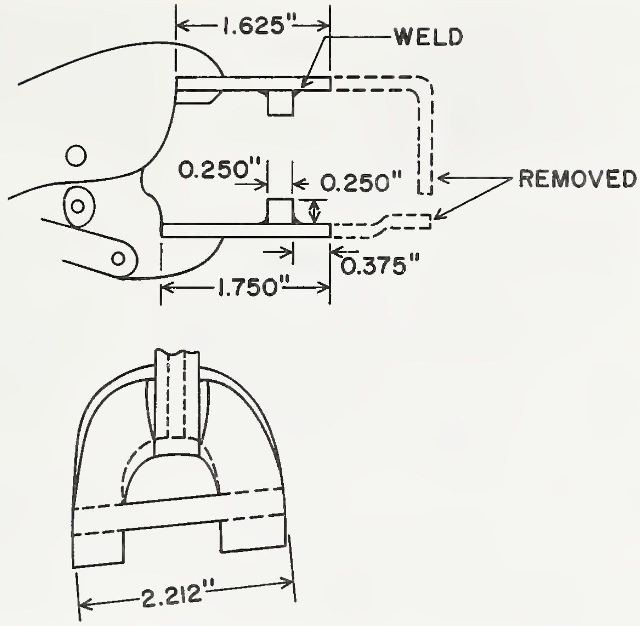

FIGURE 7.—Details of modified Vise Grip welding clamps used for holding cell mold together.

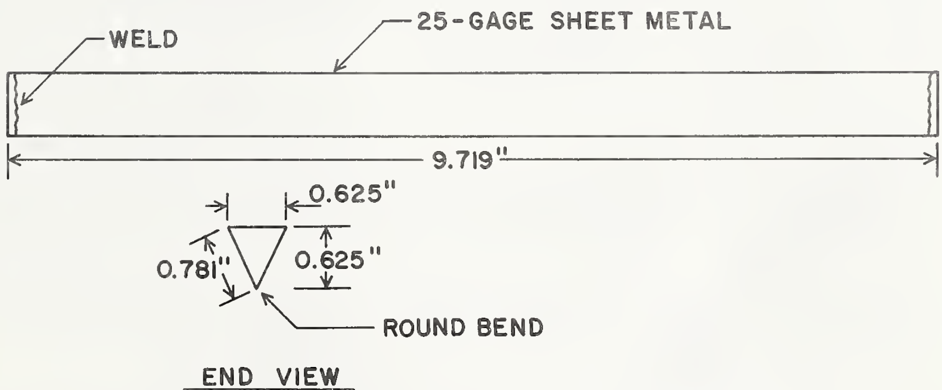

FIGURE 8.—Details of mix tray used for measuring planting mixture.

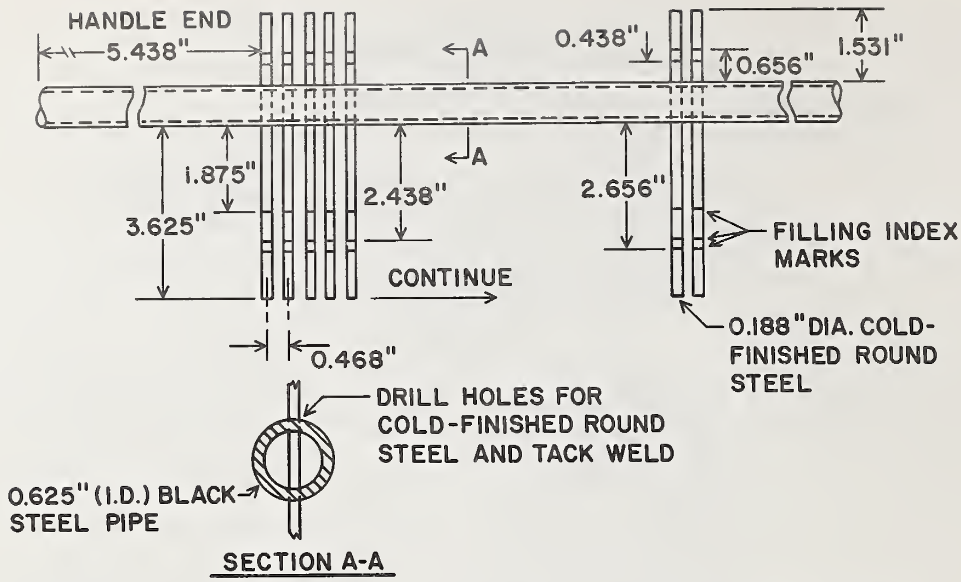

FIGURE 9.—Details of tamper used for packing planting mixture in individual cells.

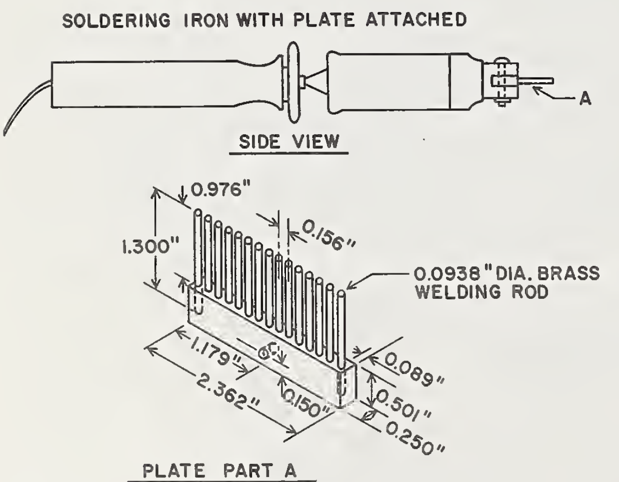

FIGURE 10.—Details of welding pins, which are attached to and heated by soldering iron, for heat-welding the plastic strips together.

C. Plastic welding

1. Soldering iron, American Beauty model 3178 (American Electrical Heater Co., Detroit, Mich.), with welding pins and holder; for heating welding pins; 110–120 V, 300 W; with standard resting stand; pin set is made by pressing brass welding rods into a copper plate (figs. 10 and 11).
2. Transformer, constant voltage (Sola Electric Co., Elk Grove, Ill.), harmonic neutralized type, cat. No. 2322150; 120 V; supplies constant voltage power to Adjust-A-Volt.
3. Adjust-A-Volt, transformer, type 3PN116B (Superior Electric Co., Bristol, Conn.); input, 120 V; output 0–140 V; 1.4 kVA; permits adjusting voltage supplied to soldering iron, thus regulating temperature of welding pins (fig. 11).
4. Water tray, used to wet bottom of bandoleer strips after they have been formed (fig. 12).

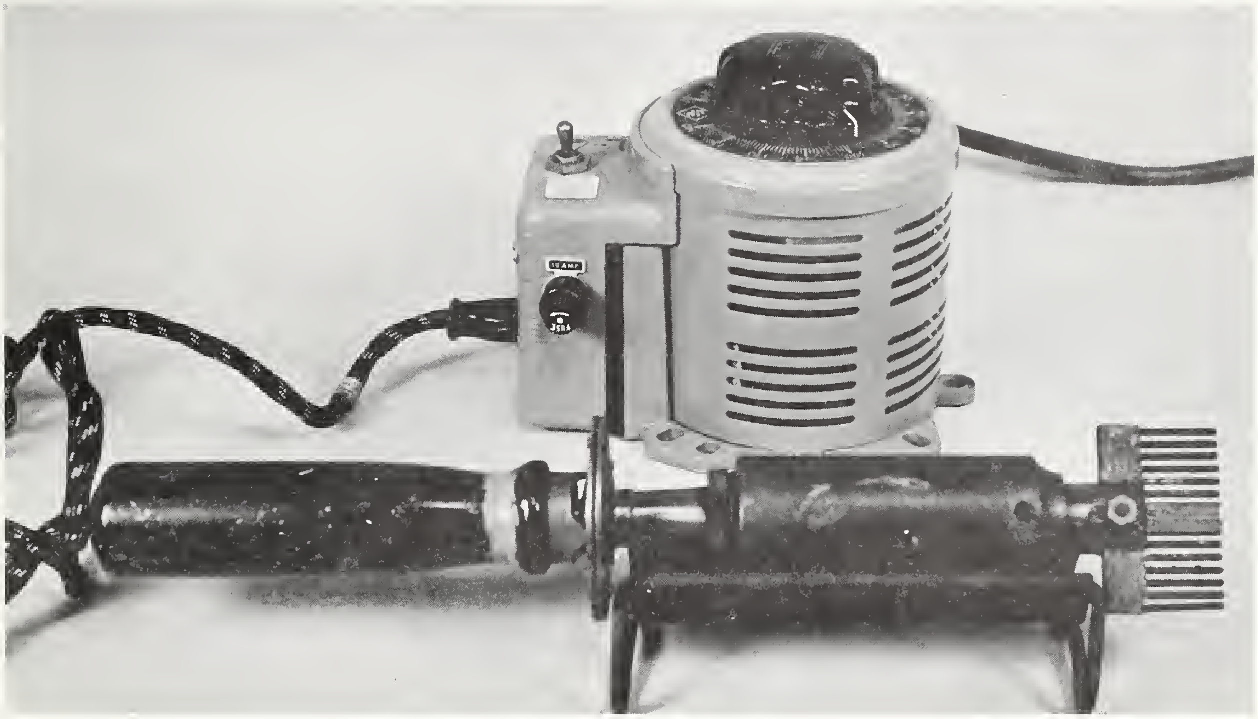

FIGURE 11.—Soldering iron, with welding-pin assembly attached, plugged into Adjust-A-Volt power stat and resting on stand. (Bar shown in center of welding plate on soldering iron was an experimental modification that was abandoned and is therefore not included on detailed drawing in figure 10.)

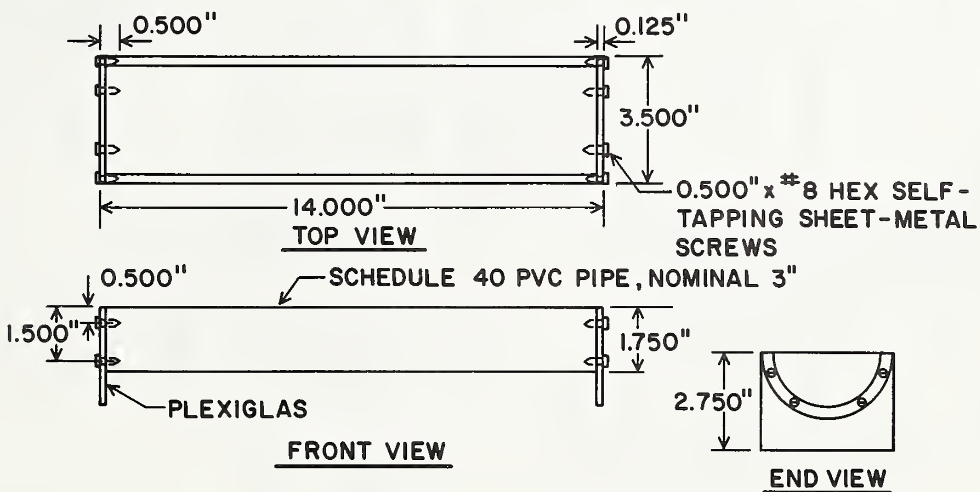

FIGURE 12.—Details of water tray used for wetting bottom of bandoleer strips after they have been formed.

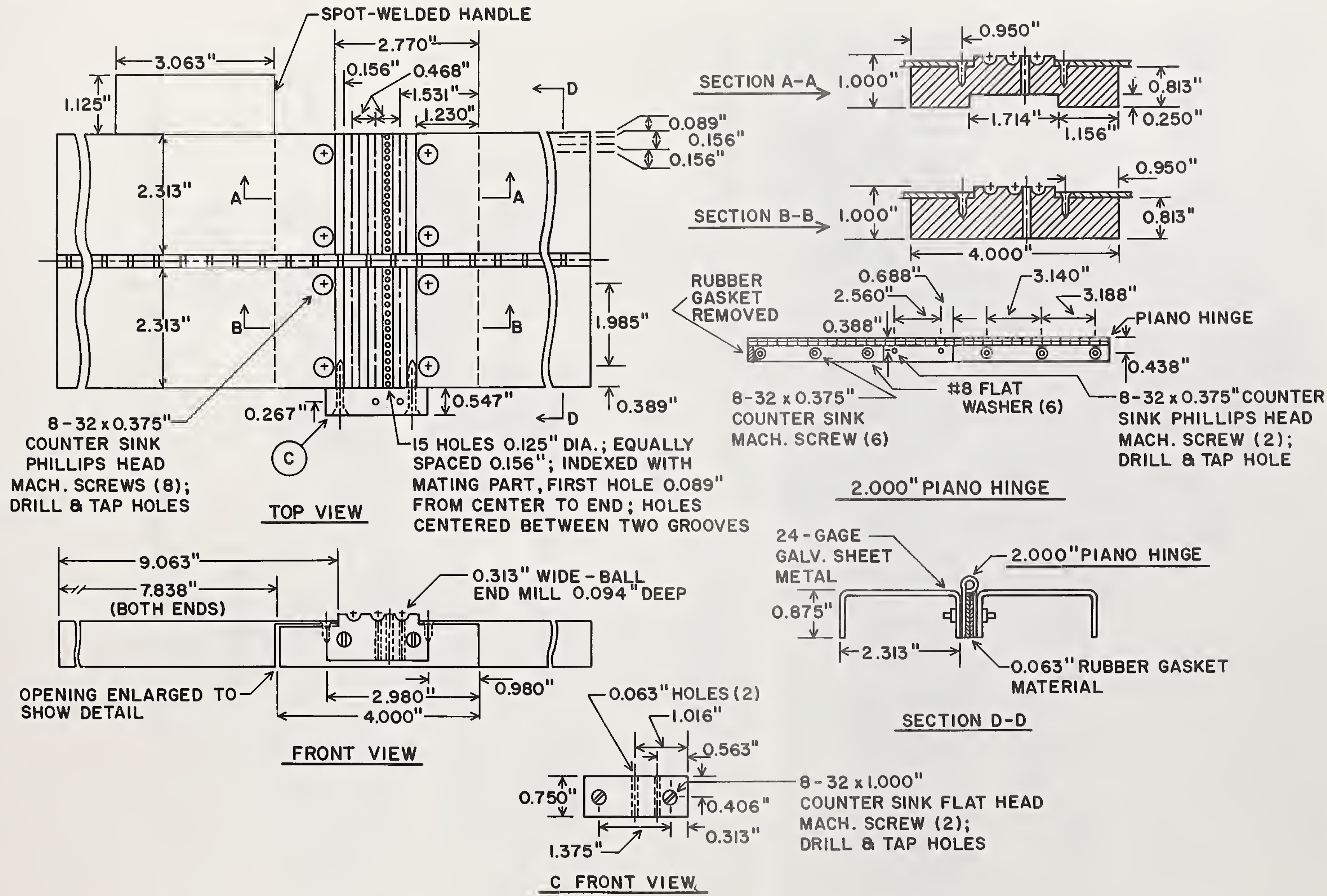

FIGURE 13.—Details of three-cell false mold used for welding two sections of bandoleer strips together.

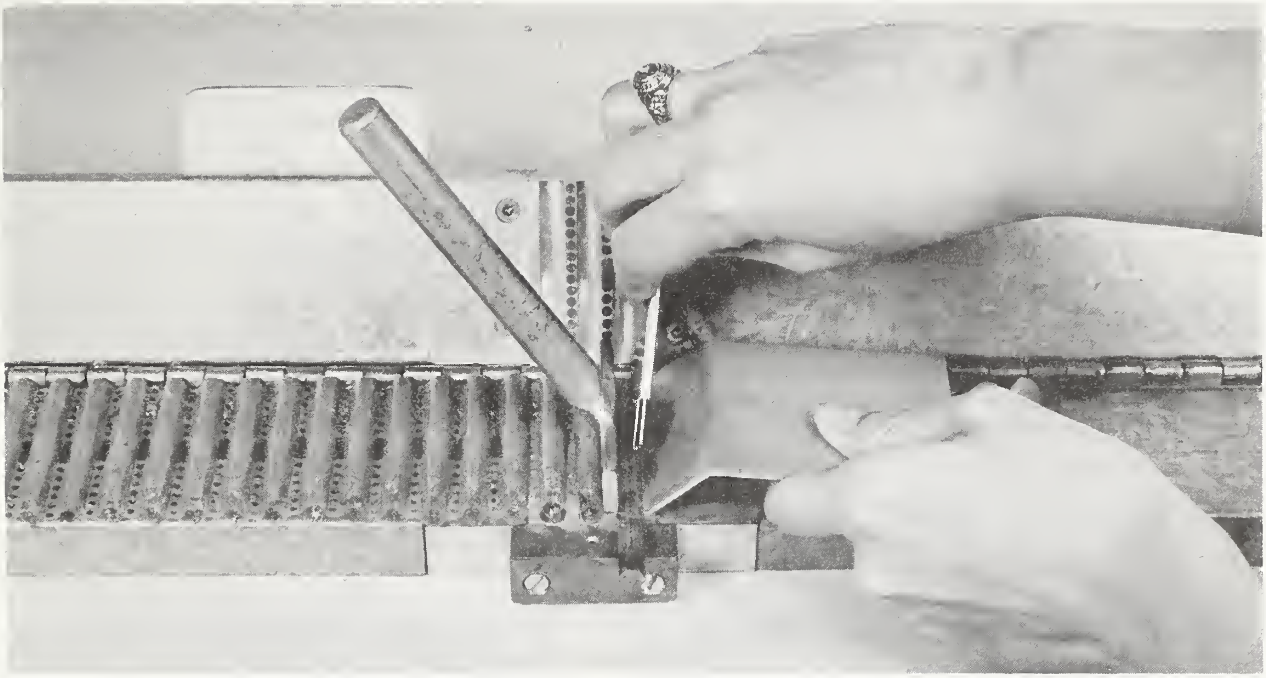

Figure 14.—Excess plastic being trimmed from bandoleer strip before two adjacent strips are joined together in three-cell false mold. (Row of holes at left of center in top half of false mold was not used.)

D. Bandoleer joining
1. Three-cell false mold, used to weld two sections of bandoleer strips together (figs. 13 and 14).
2. Index groove, used to assist in cutting plastic strip to correct length before two bandoleer sections are joined together (fig. 15).
3. Guide, used to hold plastic strip steady while excess plastic is trimmed off (figs. 14 and 16).
4. Strip holder, used to hold bandoleer strip in place while excess plastic is cut off (figs. 14 and 17).

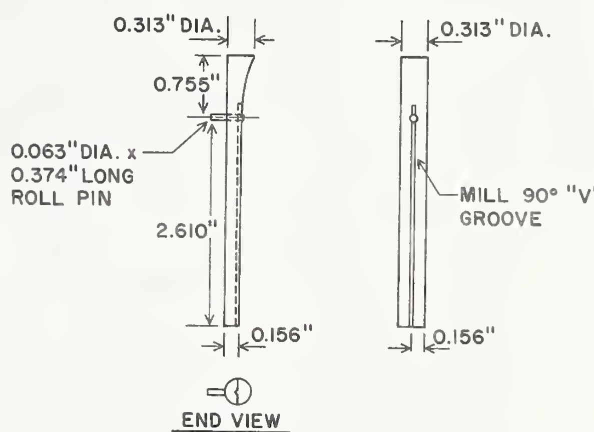

Figure 15.—Details of index groove used for assisting in cutting plastic strip to correct length before two bandoleer sections are joined together.

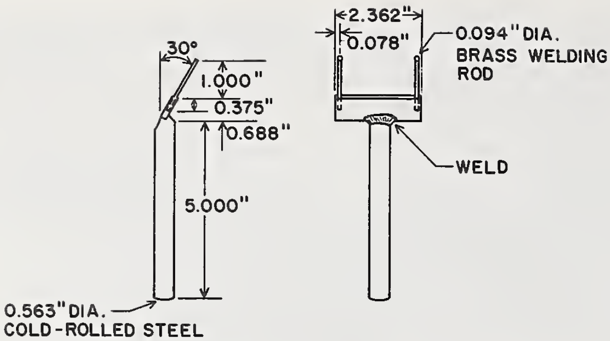

FIGURE 16.—Details of guide used for holding bandoleer strip steady while excess plastic is being trimmed off.

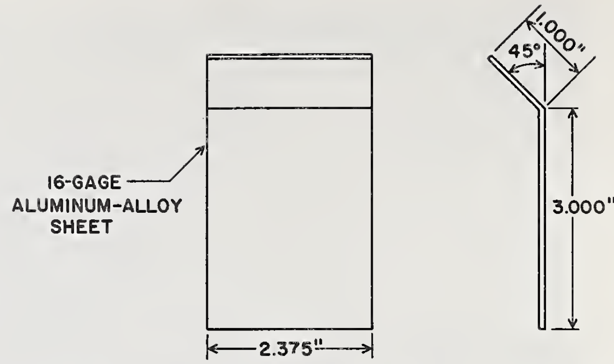

FIGURE 17.—Details of strip holder used for holding bandoleer strip in place while excess plastic is being trimmed off.

CONSTRUCTION PROCEDURES

The procedures used at Temple for making bandoleers are outlined below to assist the user in developing techniques that will fit a particular job.

During the early research efforts, Brewer (1978) thought that the weld would need to be pulled apart so that the plastic could be removed from the individual grass seedlings before they were planted in the field. This requirement resulted in a relatively weak, low-temperature weld. Such welds produced unreliable and erratic weld strength and thus caused many problems. Moden and Hauser (1982) discovered that, in fact, the plastic did not have to be removed to establish good plants. Therefore, we now use high voltage (hot pins) to make a strong, permanent weld.

The construction steps are as follows:

A. Forming the cells
  1. Warm up welding-pin unit with soldering iron (fig. 11).
  2. Connect vacuum hoses to both halves of cell mold and apply vacuum (fig. 3).
  3. Starting at one end, press 2-mil-thick plastic into grooves with the former.
  4. Attach funnel set to top of cell mold (fig. 3), and then fold the two sides of cell mold together.
  5. Hold cell mold with hand, turn off vacuum and disconnect hoses, and then clamp mold together with modified Vise Grip welding clamps (fig. 4).

B. Filling the mold
  1. Fill mix tray to top with planting mixture and pour mixture into cell mold through funnel set (fig. 4).
  2. Pack planting mixture with tamper.
  3. Fill mix tray again and pour and pack planting mixture until desired level is reached. (Seeds may be placed in individual cells before or after bandoleer strip is removed from cell mold.)

C. Welding the strip
  1. Insert hot welding pins into holes in cell mold between bandoleer cells.
  2. Remove clamps and open cell mold; lift out plastic strip with funnel set attached to top of it.
  3. Set plastic strip in water tray to wet bottom of cells and thus prevent loss of planting mixture; carefully remove funnel set.
  4. Store bandoleer strips in growing tray (fig. 18).

D. Joining the sections

After plants are established or the bandoleer cells are thoroughly wet, the sections may be handled with little or no loss of planting mixture. At this time, the sections may be joined together to form long bandoleers, as follows:
  1. Insert index groove into slot on right side of welding holes of three-cell false mold.
  2. Insert guide into outermost welding holes, and push it through the strip.
  3. Use strip holder to keep excess plastic straight.
  4. Cut off excess plastic with single-edge razor blade guided by index groove (fig. 14).
  5. Use strip holder to hold strip down, then remove guide.
  6. To trim left end of another strip, move in-

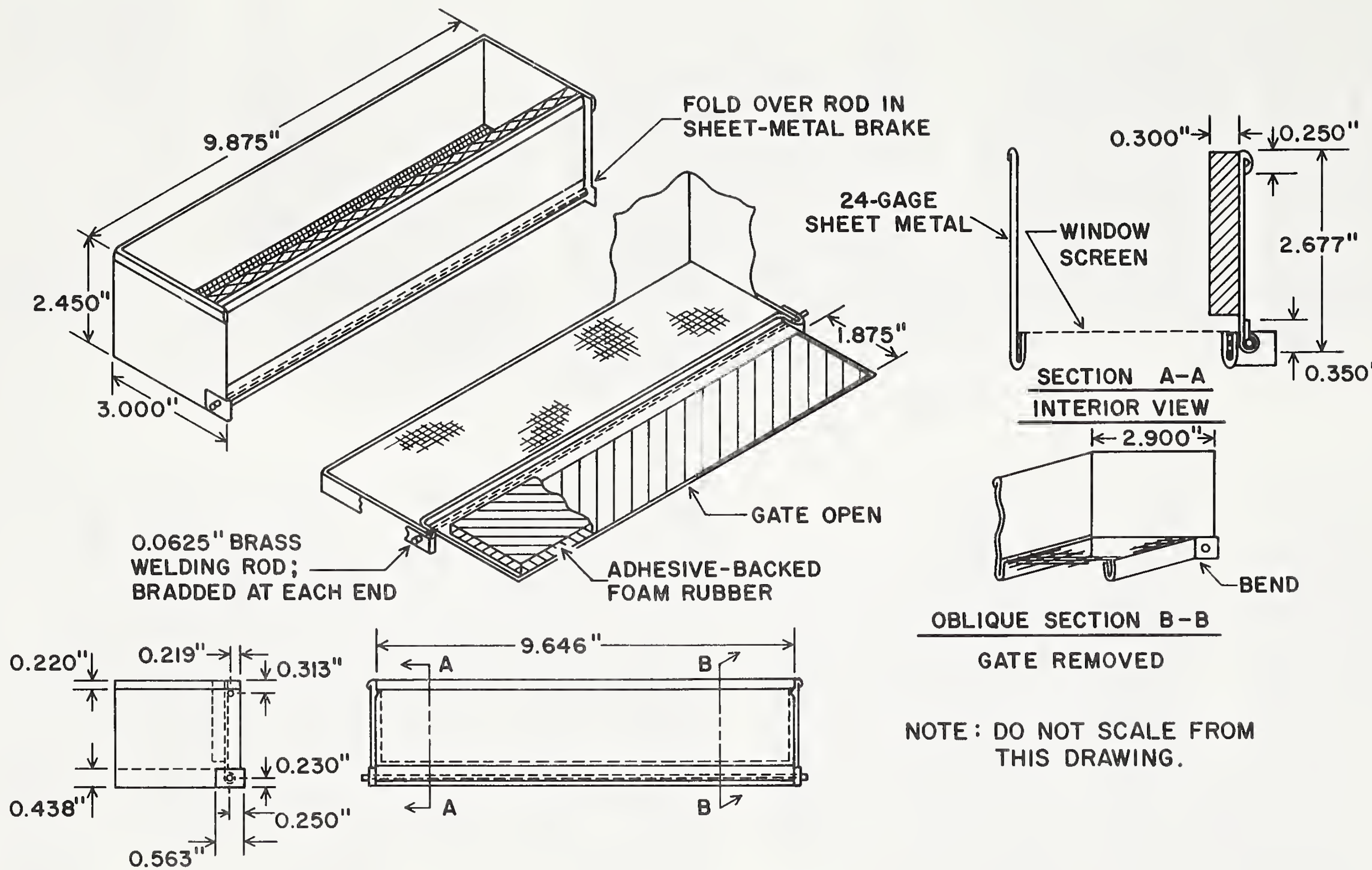

FIGURE 18.—Details of growing tray used for holding bandoleers while plants are being grown in them.

dex groove to slot on left side of welding holes and follow same procedure as before.

7. Set cut ends together, laying one over the other and alining holes with those of mold.
8. Fold top of false mold over and insert welding pins into holes to weld the two sections together.

E. Correcting a weld

If a suitable weld is not made or if the strip is cut in two, the problem can be resolved by using either of the following methods:

1. Fold over remaining plastic at weld and weld it again.
2. Slice open one bandoleer cell at end of each bandoleer section, remove planting mixture from each cell, and use exposed plastic to weld sections together as described above in section D.

GREENHOUSE PROCEDURES

The special growing tray (fig. 18) was designed at Temple to hold the bandoleers while plants are being grown in them in the greenhouse. It consists of a single piece of sheet metal, bent to form three sides, and a second piece for the gate. A third piece of sheet metal forms the lower frame on the gate side of the tray. A window screen forms the bottom, which allows air circulation to prune the roots of the grass seedlings if the tray rests on an open bench. Air-pruning of the roots prevents root entanglement and promotes easy separation of the plants.

The tray secures the bandoleers and holds the dry mixture in the cells. The bandoleers are easily wetted by immersing the tray in water or nutrient solution. (However, in our study the tops of the cells were not covered by liquid.) The bandoleers can also be wetted by spraying the tops of the plants, but, for experimental purposes with small numbers of plants, the immersion method is easier.

The procedures for growing plants in bandoleers in the greenhouse are as follows:

A. Establishing the plants

1. Bandoleer cells not seeded
   - (a) Soak bandoleers in distilled water.
   - (b) Plant two or three seeds at an appropriate depth in each cell and cover with vermiculite or other media.
2. Bandoleer cells previously seeded
   - (a) Soak bandoleers overnight in distilled water.
   - (b) The next day, put tray of bandoleers in plastic bag, then inflate bag. Place tray in greenhouse under shade cloth that gives about 50% shade. (It is important to avoid contact between wet plastic bag and growing plants to reduce fungal attack.) Alternate step 2b: place bandoleers in humid growing chamber until most cells contain emerged seedlings.
   - (c) When most cells contain growing plants, remove plastic bag and grow seedlings underneath shade cloth.

B. Stock and nutrient solutions

In our study, the bandoleers were soaked in modified Hoagland's nutrient solution (Hoagland and Arnon 1938) on the 10th to 14th day after signs of germination. (Water or nutrient solution should be applied as needed to balance the evaporation demand of the greenhouse and supply adequate nutrients for plant growth.) The modified solution provided the essential elements needed by the grass seedlings.

To avoid making the formula each time it is used, stock solutions are prepared and refrigerated for each component. However, refrigeration of KNO_3 may cause precipitation. If precipitation occurs, set the container in a dark place at room temperature for a few hours and it will return to solution.

1. Making stock solutions
   - (a) Macronutrients: Make up 1 liter of each solution separately with distilled water.

Compound	*Solution concentration (grams/liter)*
$Ca(NO_3)_2 \cdot 4H_2O$	236.1
KH_2PO_4	136.1
KNO_3	101.1
$MgSO_4 \cdot 7H_2O$	246.4

(b) Micronutrient mixture: Combine the given amounts for all compounds into 1 liter of solution with distilled water.

Compound	*Solution concentration (grams/liter)*
H_3BO_3	2.86
$MnCl_2 \cdot 4H_2O$	1.81
$ZnCl_2$	0.11
$CuCl_2 \cdot 2H_2O$	0.05
$NaMoO_4 \cdot 2H_2O$	0.025

(c) Iron: Make up 1 liter of the iron solution separately with distilled water.

Compound	*Solution concentration (grams/liter)*
Geigy Sequestrene 138 Fe chelate.	27.0
or	
Geigy Sequestrene 330 Fe chelate.	16.2

2. Making nutrient solutions

The amount of each stock solution needed to mix 1 liter of nutrient solution is given below. It is important to add the nutrients in the order that they are listed to avoid precipitation.

(a) Macronutrients

Solution	*Milliliters of solution*
$Ca(NO_3)_2 \cdot 4H_2O$	5
KNO_3	4
KH_2PO_4	2
$MgSO_4 \cdot 7H_2O$	2

(b) Micronutrients and iron

Solution	*Milliliters of solution*
Micronutrient mixture	1
Fe chelate	3

C. Mixing procedure for nutrient solution

Check pH at the points indicated below and add the amount of 0.1 *N* HCl or NaOH needed to adjust the pH to a range of 5.5–6.0.

1. Measure initial pH of distilled water and, if necessary, adjust to 5.5–6.0 range.
2. Add macronutrients to 500 milliliters of distilled water, mixing well after each addition.
3. Check pH; adjust to 5.5–6.0 range.
4. Add micronutrient mixture and iron chelate solution, mixing well after each addition.
5. Add distilled water to bring volume up to 1 liter.
6. Check final pH, which must be in 5.5–6.0 range.

D. Precautions

1. Allow at least a 1-minute time lapse after each addition listed above before taking pH reading to allow for completion of mixing and chemical reactions.
2. Use nutrient solution within 1 week, and store it in the dark.

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